SPACE-O

Workshop on using Water Quality Forecasting in Decision Making

Singapore, July 10th 2018

Water Information System (WIS)

Evangelos ROMAS
EMVIS SA

SPACE-O concept…

Space Assisted Water Quality Forecasting Platform for Optimized Decision Making in Water Supply Services

Problem

Harmful algae blooms and increased turbidity in surface water reservoirs used for drinking water production pose a threat on human health and water resources sustainability

Opportunity

Real time short term forecasting of water quantity and quality can facilitate proactive decision making and allow downstream water infrastructure to operate efficiently in terms of water quality and financial performance

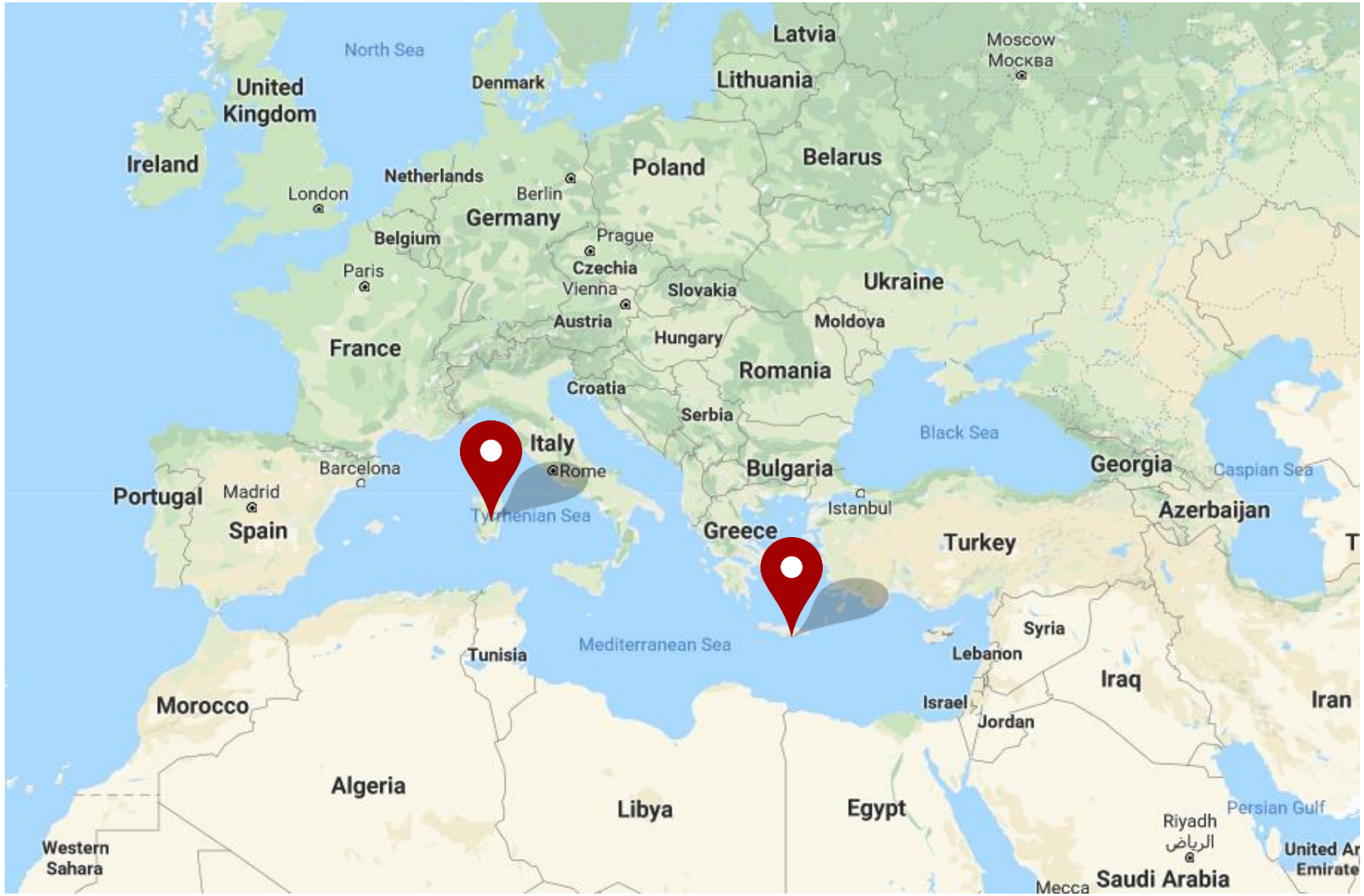
Solution

Combine
- EO derived water quality
- Ground monitoring stations
- Hydrological modelling in upstream catchments
- Hydrodynamic and water quality modelling in reservoir

Produce
short to medium range water quantity and quality forecasts (7-10 days)

Integrate
into a comprehensive DSS offering operations and performance optimization in Water Treatment Plants.

Meet our case studies.



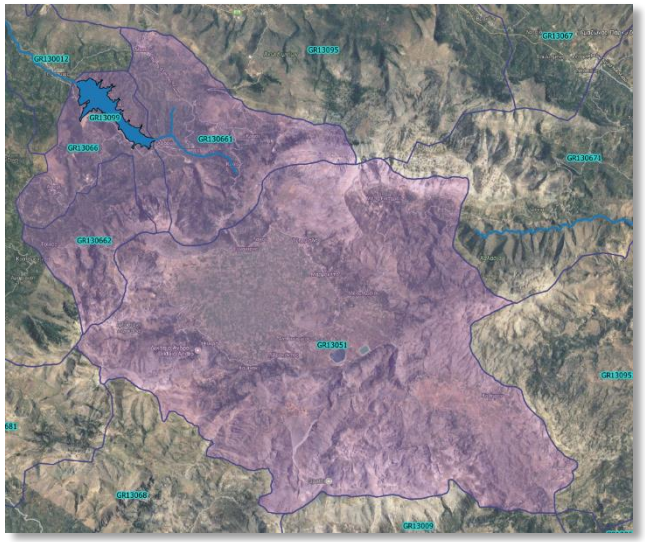
1. Aposelemis dam, Crete, Greece
2. Mulargia dam, Sardinia, Italy

Case studies (a)

Aposelemis dam (Crete, Greece)

ORGANIZATION FOR THE
DEVELOPMENT OF CRETE S.A.

Dam height	50 m
Reservoir area	1,6 km2
Capacity	27 hm3
Upstream catchment area	62 km2
Rainfall	800 mm/year



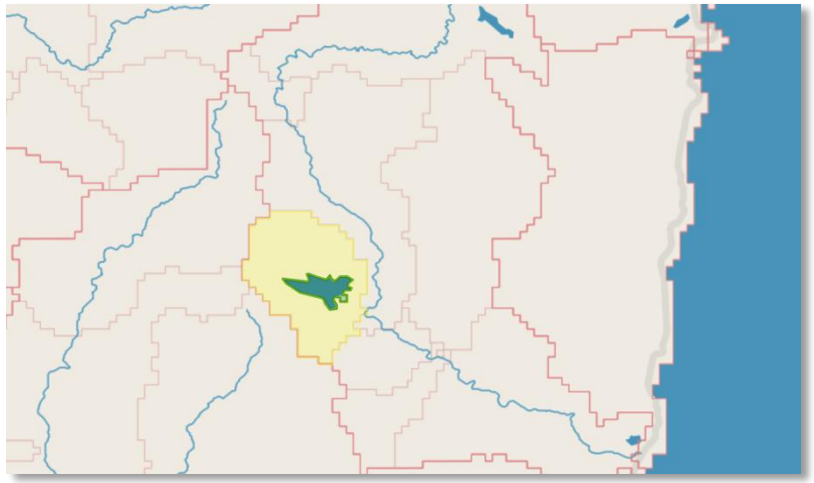
Capacity	110.000 m3/day
Units	• Ozonation • Flocculation & sedimentation • Filtration in sand beds • Chlorination • Sludge thickening • Sludge dewatering

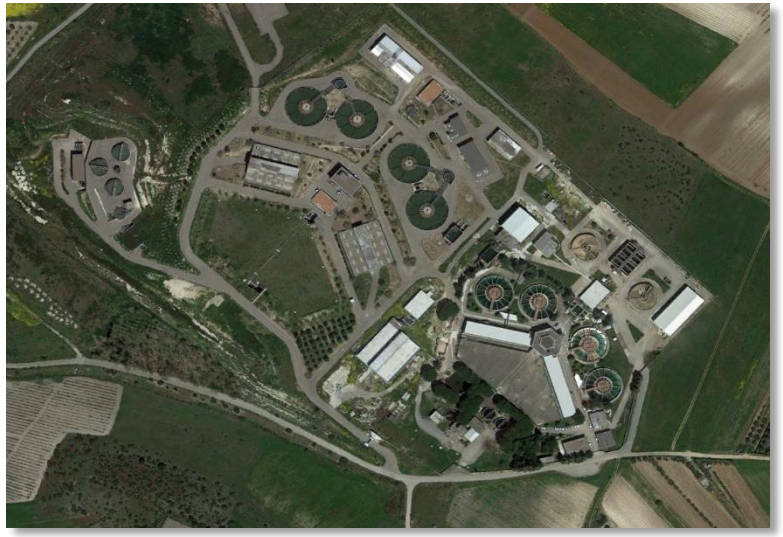
Case studies (b)

Mulargia dam (Sardinia, Italy)

ENAS Sardegna

Dam height	99 m
Reservoir area	12 km2
Capacity	347 hm3
Upstream catchment area	178 km2
Rainfall	600 mm/year





Capacity	155.000 m3/day
Units	• Microalgae removal • pH Correction • Pre-oxidation and disinfection • Coagulation-Clarification • Filtering with sand and anthracite filters • Post-ozonisation • Active carbon filters • Final disinfection with chlorine dioxide • Treatment and recovery of rinse waters • Sludge treatment

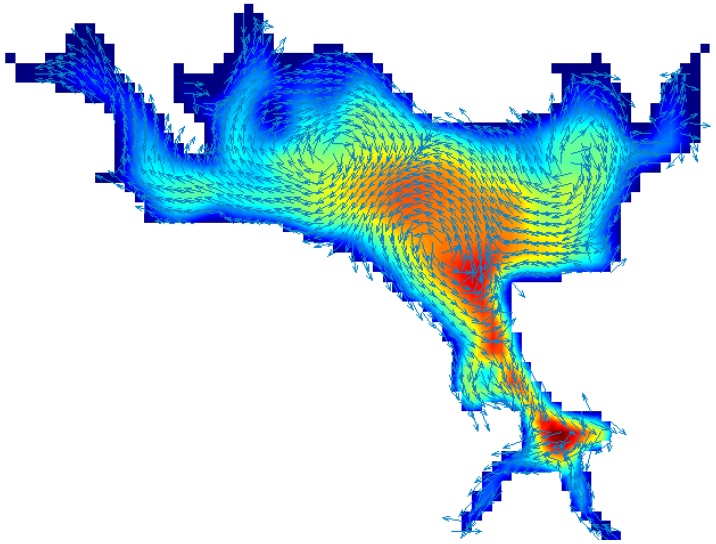
The science behind the service… (1/2)

Hydrological Forecasting

- Hydrology (E-HYPE & GR-HYPE)
- ECMWF Deterministic, ECMWF EPS (51 members), NOA's high-resolution
- Up to 10 days forecasts of river discharges, water temperature, sediment and nutrient loads

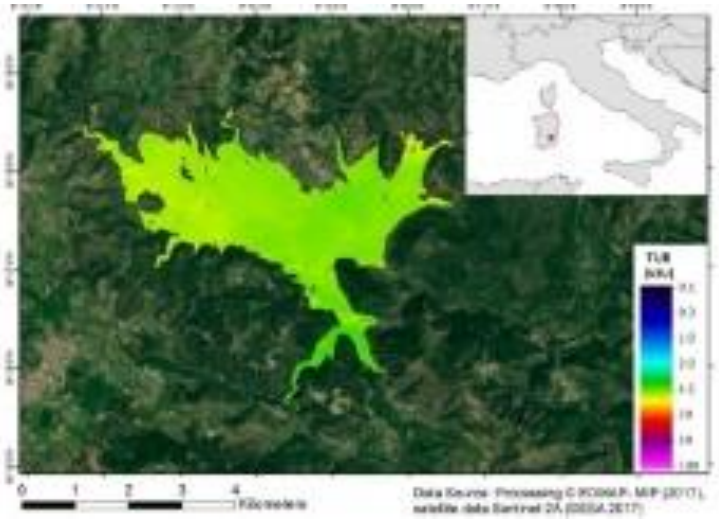
Water Quality Forecasting

- 3D Hydrodynamic modelling (Delft3D-FLOW)
- Water quality modelling (DELWAQ)
- Up to 10 days forecasts of water levels and concentrations of key water quality parameters (chlorophyll, sediments, nutrients, dissolved oxygen)



Earth Observations

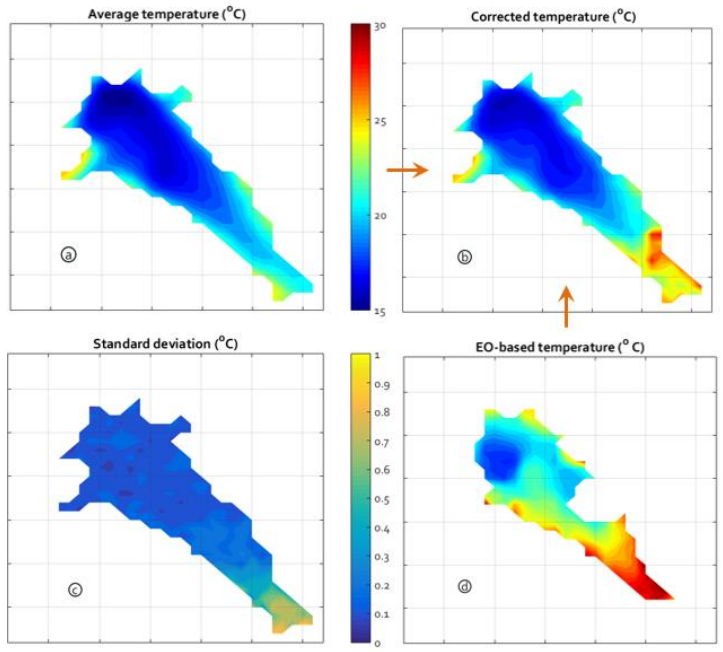
- EO products (chlorophyll, turbidity, water temperature)
- Sentinel-2A/B, Landsat 7&8, World View 2/3 (VHR)



The science behind the service…(2/2)

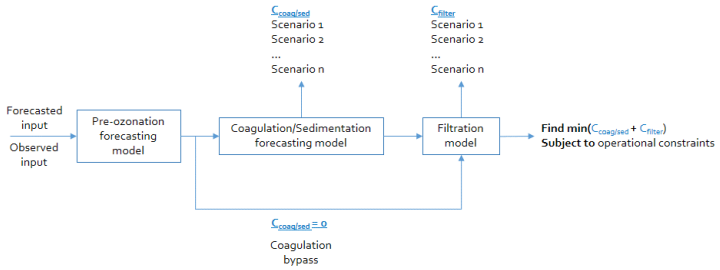
Data Assimilation

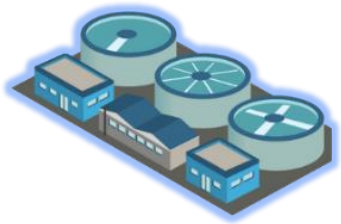
- Near real-time data assimilation of in-situ monitoring datasets and EOs to improve model performance using the Ensemble Kalman Filter technique



Process Simulation

- Machine learning techniques for the simulation of pre-ozonation, coagulation-sedimentation and filtration stages
- Minimization of functional costs of the WTP





Decision Support System

- Water Information System
- Early Warning System
- Treatment Plant Optimization
- Catchment Risk Assessment
- Citizens Science

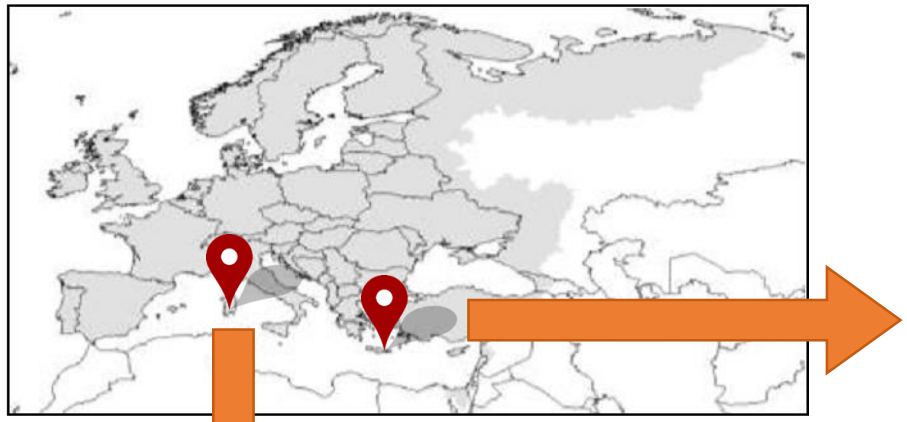
Hydrology

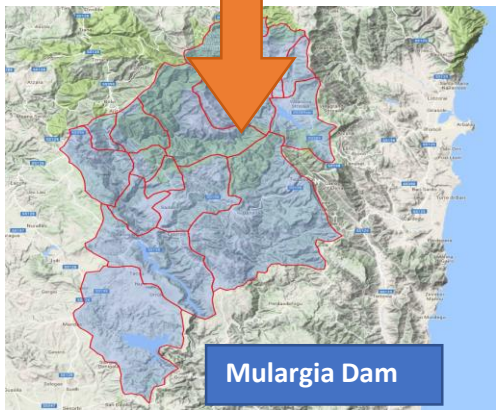
Hydrological Forecasting

- Hydrology (E-HYPE & GR-HYPE)
- ECMWF Deterministic, ECMWF EPS (51 members), NOA's high-resolution
- Up to 10 days forecasts of river discharges, water temperature, sediment and nutrient loads

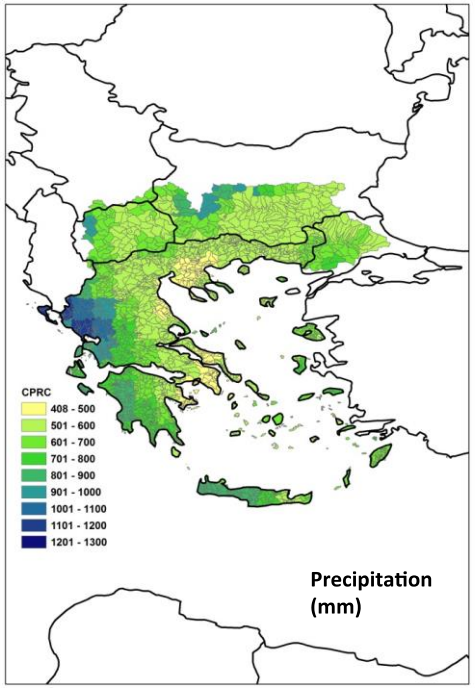
- Hydrological modelling is performed in the upstream hydrological catchments of the selected reservoir.
- Hydrological modeling estimates the amount of water entering the reservoir as well as its quality characteristics e.g. temperature, nutrients (Nitrogen and Phosphorus) and suspended sediments.
- Up to 10 days forecasts

E-HYPE v.3.0





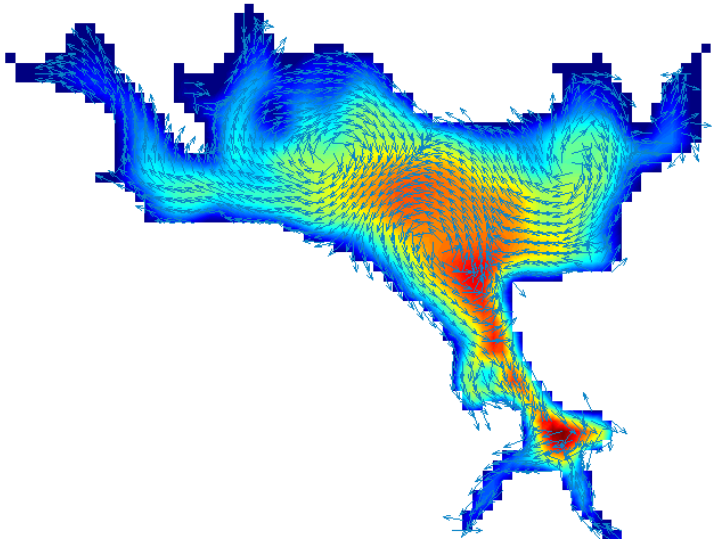
GR-HYPE v.1.0



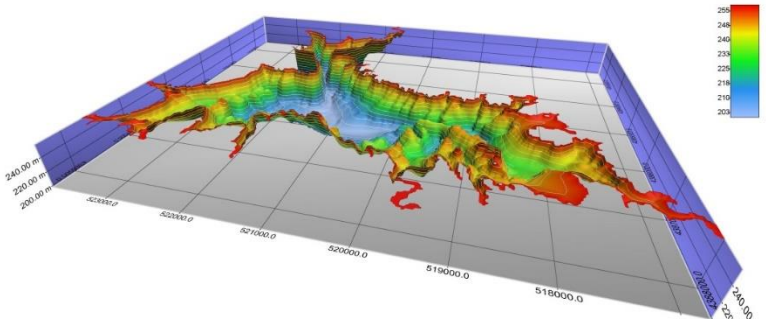
Water Quality

Water Quality Forecasting

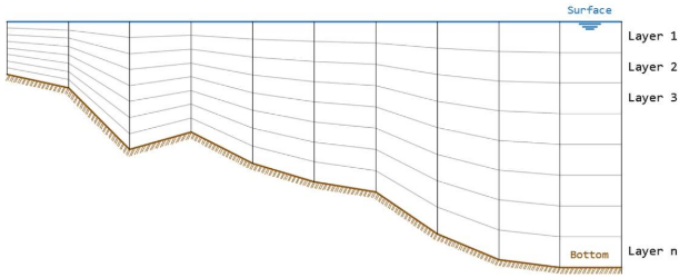
- 3D Hydrodynamic modelling (Delft3D-FLOW)
- Water quality modelling (DELWAQ)
- Up to 10 days forecasts of water levels and concentrations of key water quality parameters (chlorophyll, sediments, nutrients, dissolved oxygen)



- Hydrodynamic & Water Quality forecasting is performed inside the reservoir which is reservoir is divided in vertical layers.
- Hydrodynamic modelling captures the motion of the water inside the reservoir due to wind, temperature currents, and momentum exchange in boundaries (river mouths, abstraction points etc.). Estimates water levels and velocity vectors.
- Water quality modelling simulates more than 50 active processes (algae growth, nitrification, re-aeration and oxygen sediment demand)
- We are able to estimate concentrations of algae, sediments, nutrients, dissolved oxygen, temperature for the entire reservoir
- Up to 10 days forecasts of water levels and water quality characteristics.



Mulargia reservoir is discretized in the hydrodynamic and water quality model in 15 vertical layers. The depth of each layer depends on the water depth in each computational cell.



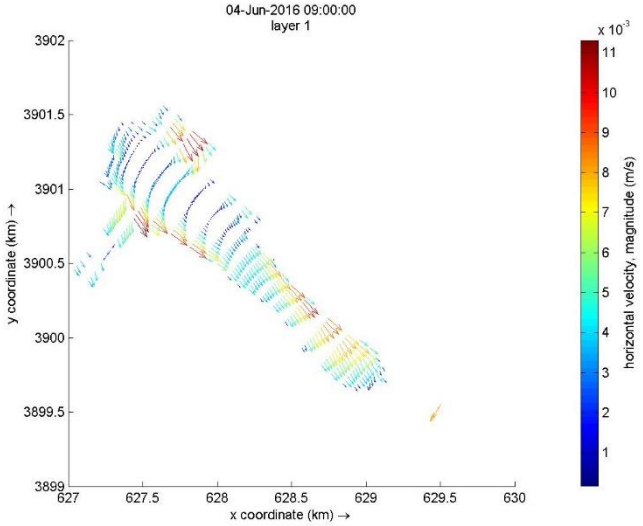
Hydrodynamic and Water quality forecasting

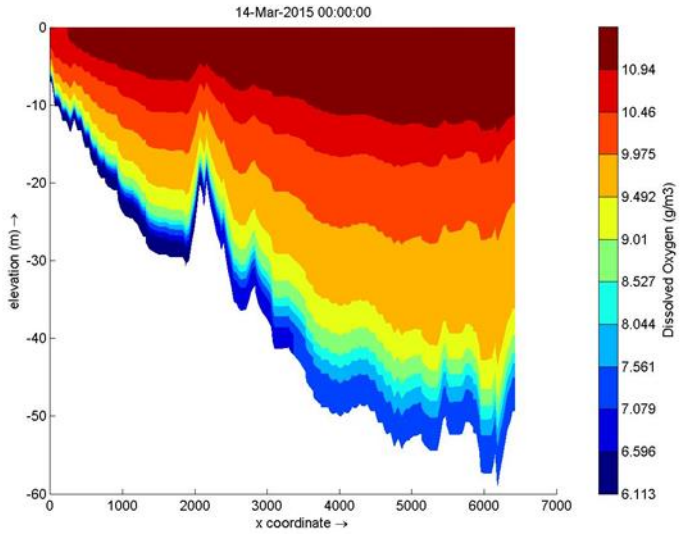
3D hydrodynamic and water quality reservoir modelling using Delft3D modeling framework

Hydrodynamic simulation

Capture the motion of water and calculate the forces acting on it

- Water velocities
- Mixing and turbulence
- Water temperature and densities





Water quality simulation

16 state variables

- Dissolved oxygen
- Suspended inorganic matter
- Inorganic dissolved & particulate nutrients
- Particulate & dissolved organic matter
- Two algal populations

50 active processes

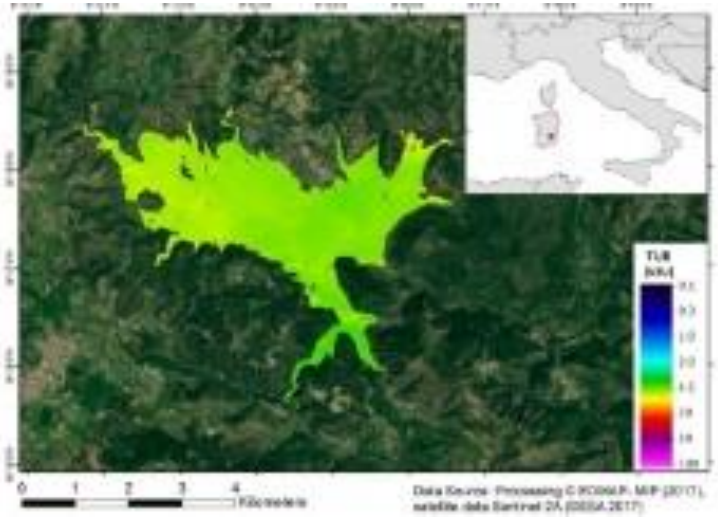
- Transport
- Exchange on the bed-water interface
- Primary production
- Light extinction
- Mineralization processes
- Nitrification, denitrification, sorption & desorption
- Re-aeration and sediment oxygen demand

Up to 10-day forecasts of water levels and key water quality parameters (chlorophyll, sediments, nutrients, dissolved oxygen)

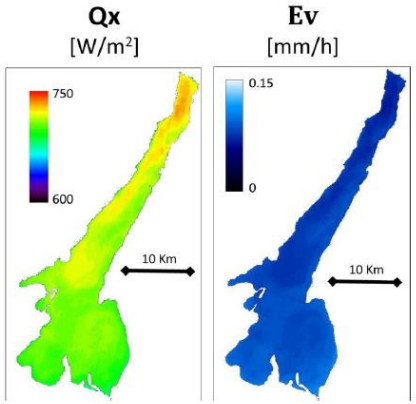
Earth Observations

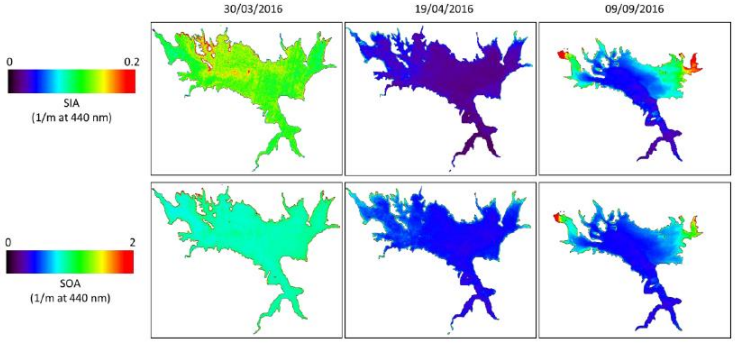
Earth Observations

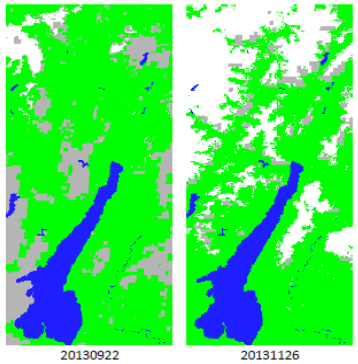
- EO products (chlorophyll, turbidity, water temperature)
- Sentinel-2A/B, Landsat 7&8, World View 2/3 (VHR)



- Satellite images have a large geographical coverage compared to in-situ stations.
- Their temporal resolution is about 1-2 images available every week.
- Satellite images allow us to estimate in near real time parameters like Chlorophyll-a, turbidity, water temperature for the surface layer of Reservoir.
- Images available from **Sentinel-2A/B** and **Landsat 7&8** missions offering 10 m and 30 m resolution respectively.
- More parameters are available from EO, eg Organic and Inorganic suspended matter, Scums and Oils, Snow Cover, Hydrological quantities.

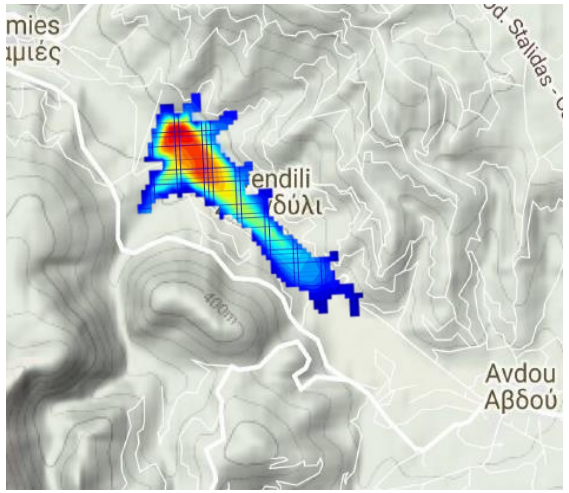


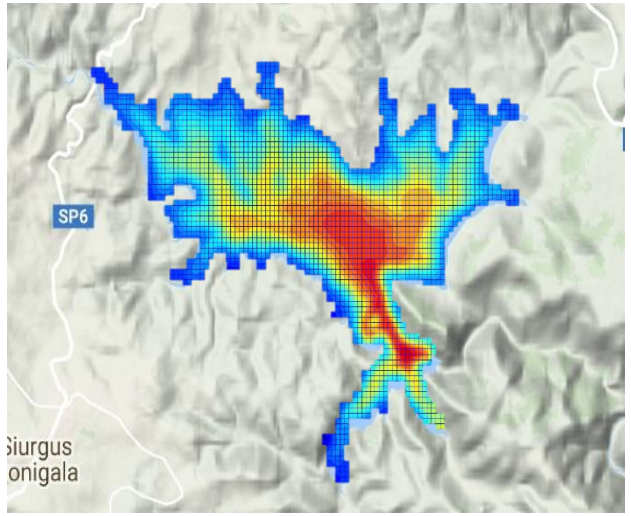




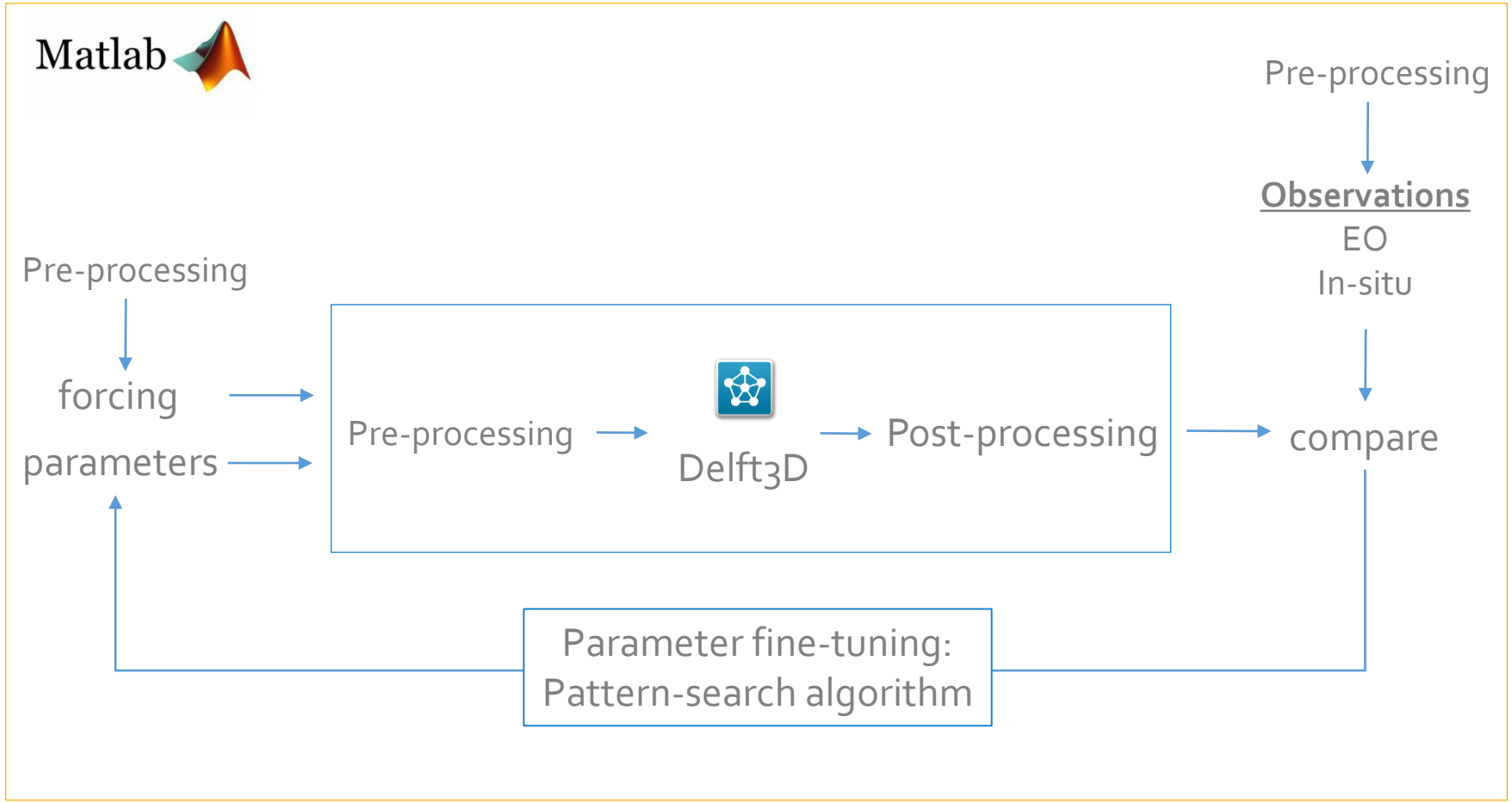
Snow cover

Improving Model Performance
→ Model Calibration





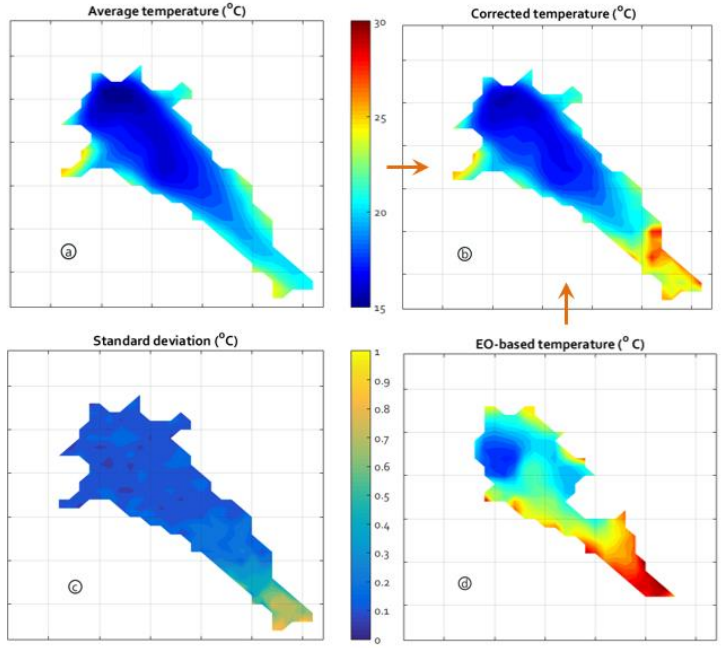
- Main objective
  - Minimize the discrepancy between model output and observations



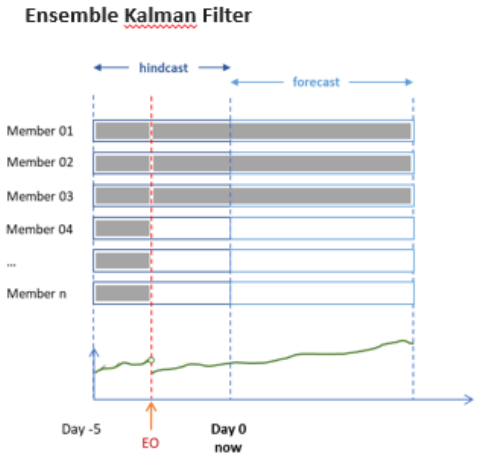
Improving Model Performance
→ Real-time Data Assimilation

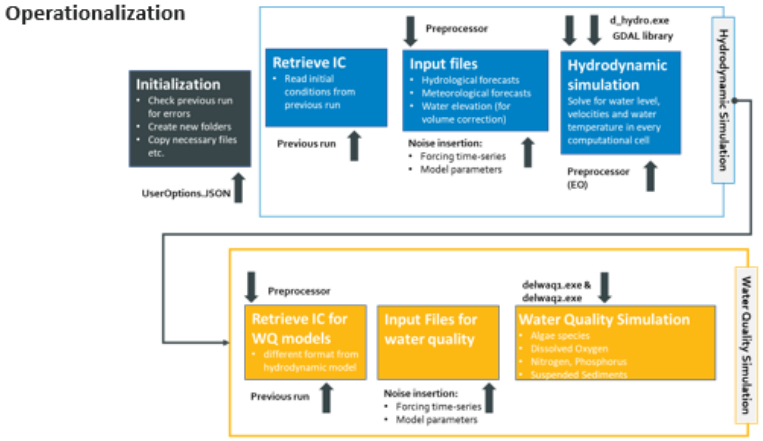
Data Assimilation

- Near real-time data assimilation of in-situ monitoring datasets and EOs to improve model performance using the Ensemble Kalman Filter technique

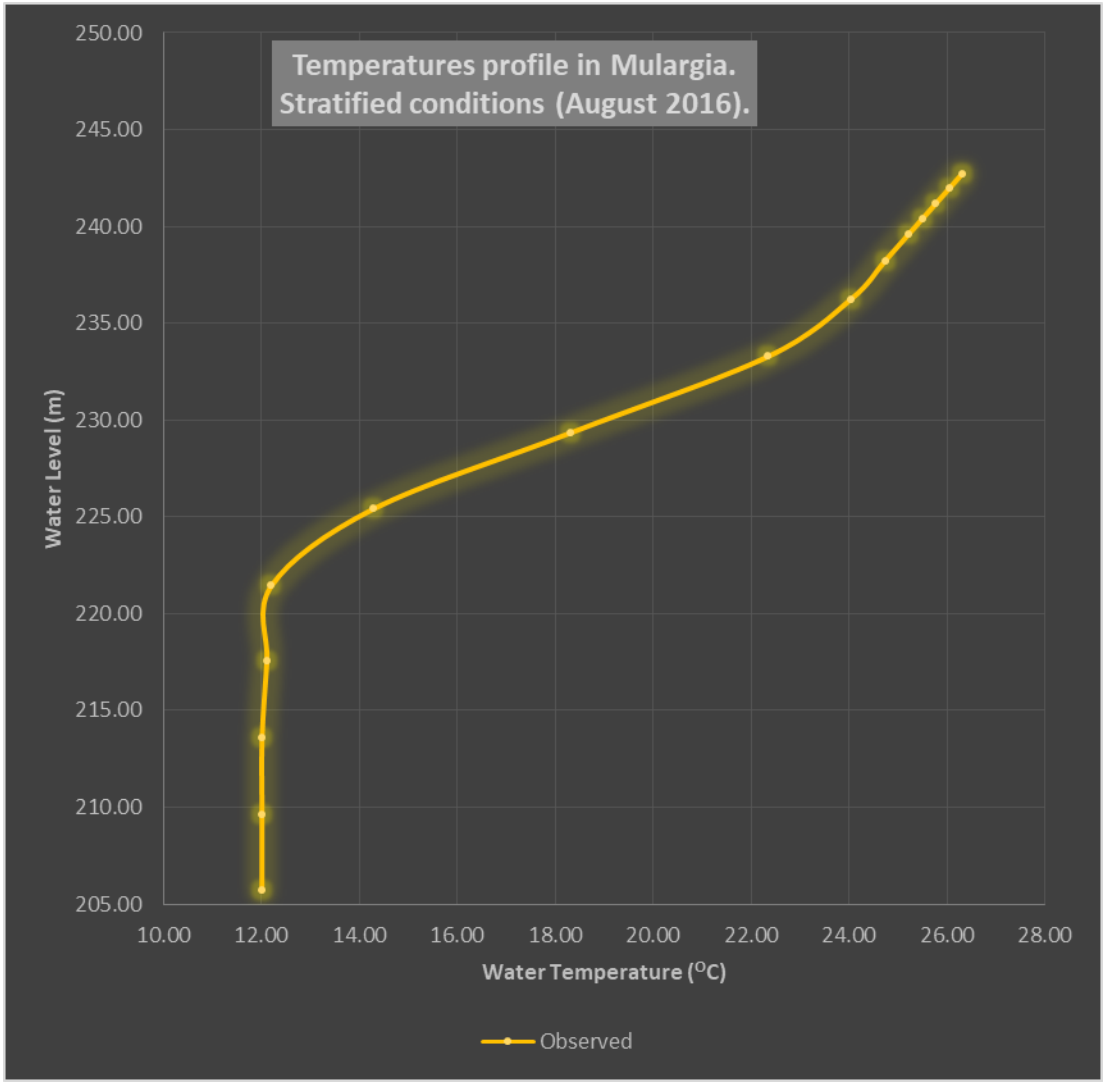


- Satellite images (when available) and datasets from in-situ monitoring stations are used to in real time to correct the initial conditions of the models and increase the predictive capacity of water quality forecasting.
- Advanced data assimilation techniques (Ensemble Kalman Filter) have been developed and incorporated in SPACE-O service line.



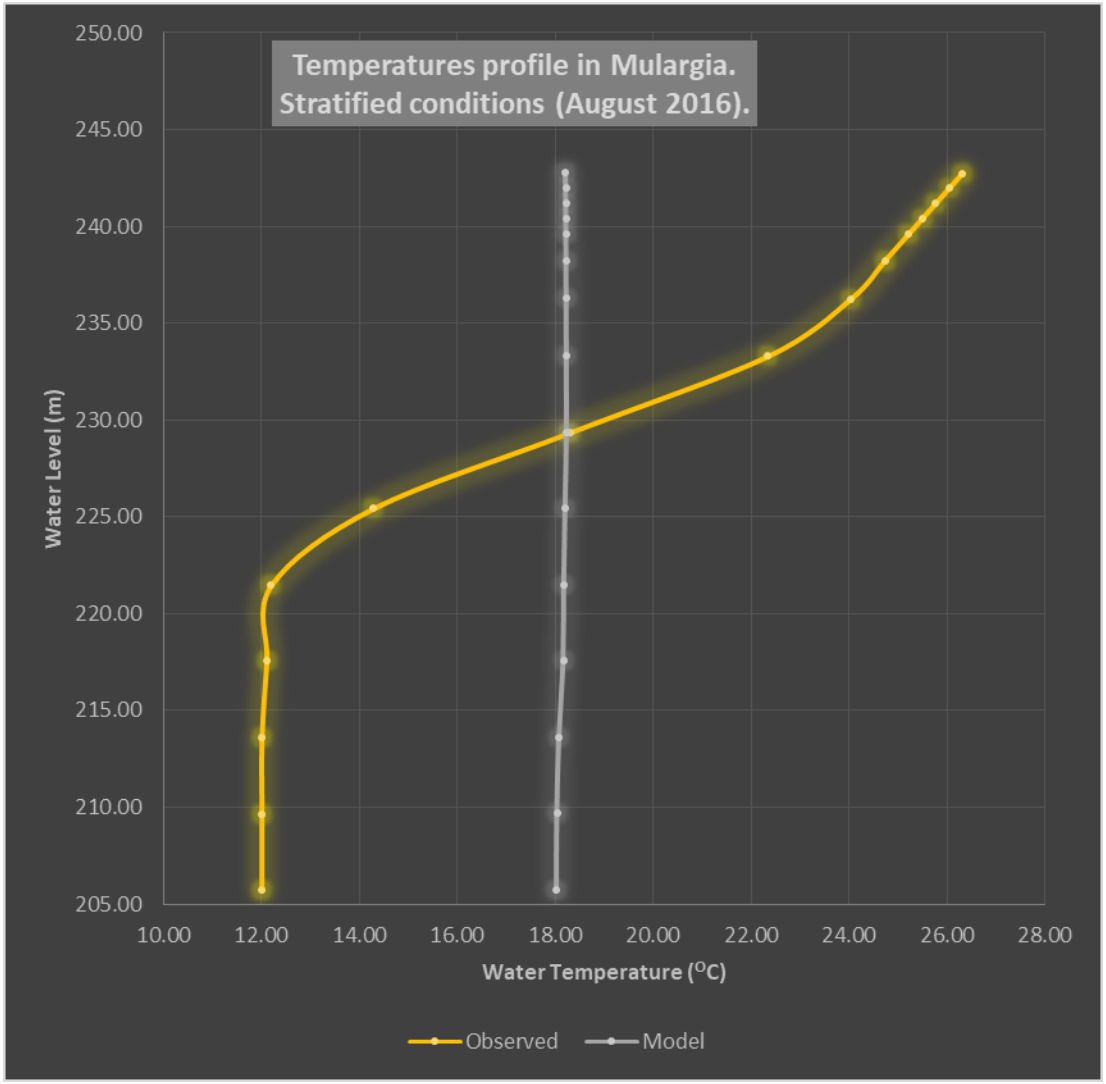


Performance of hydrodynamic model



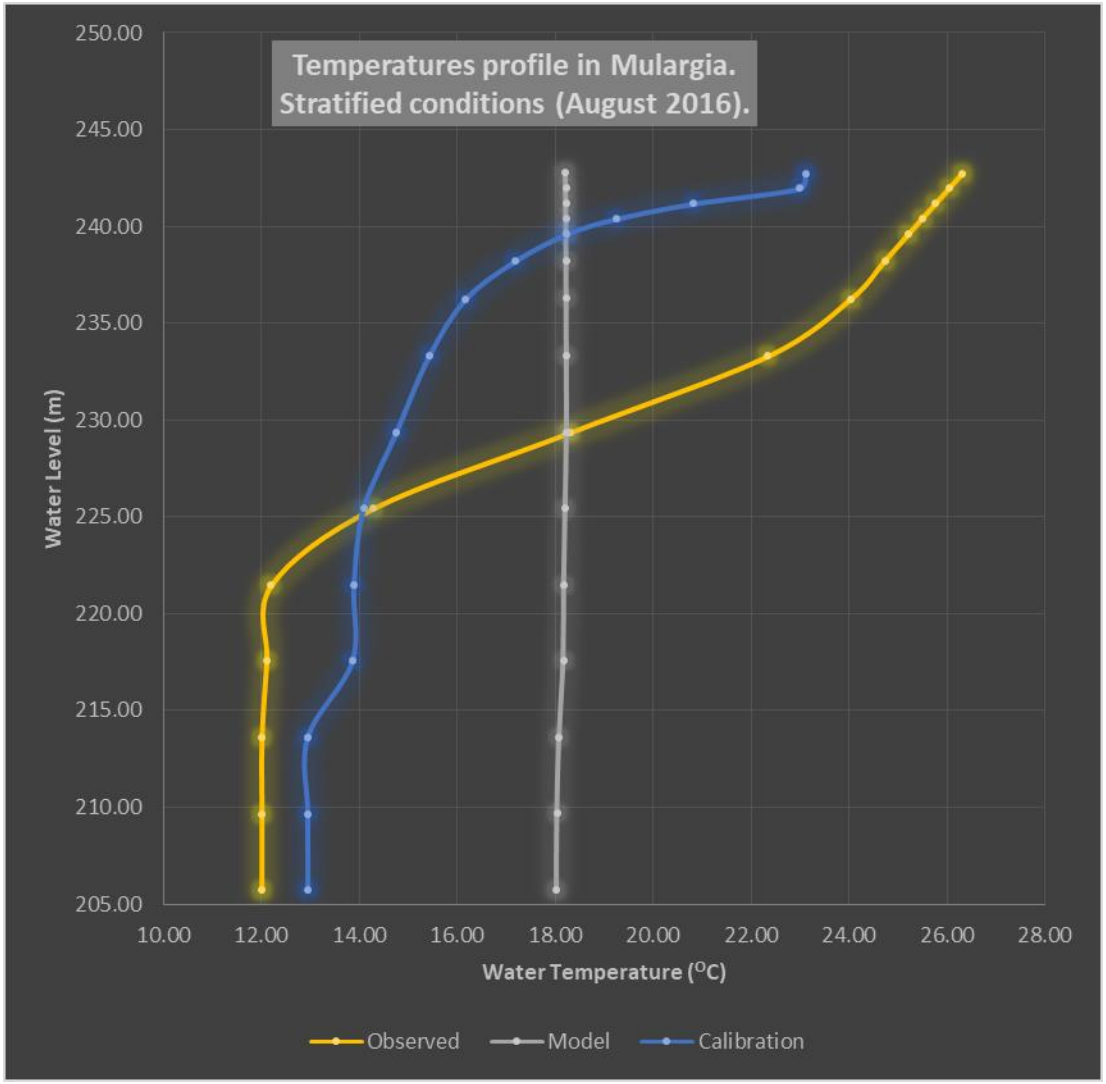
- Temperature profiles is an efficient way to judge hydrodynamic model performance.

Performance of hydrodynamic model



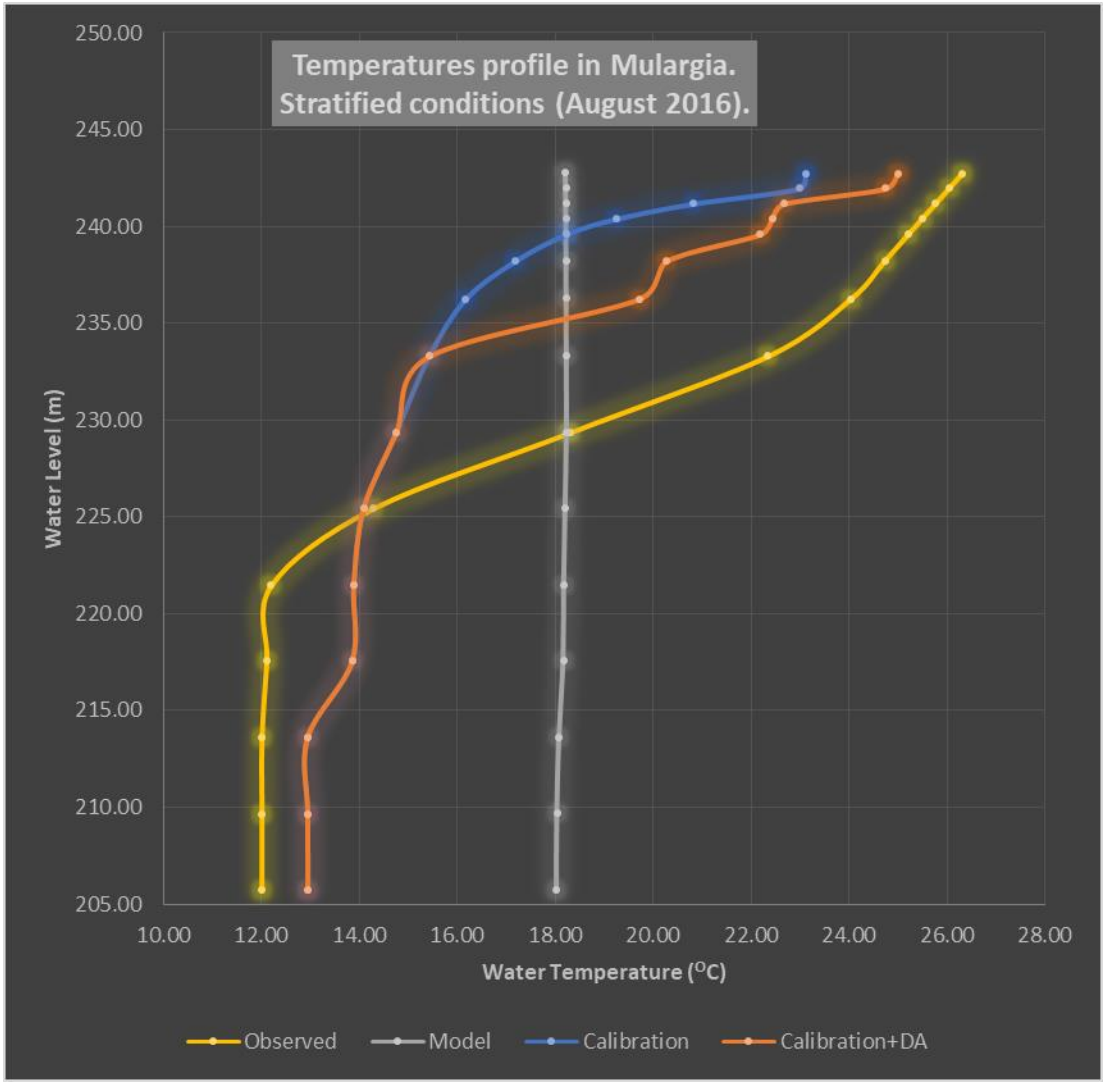
- Temperature profiles is an efficient way to judge hydrodynamic model performance.
- Model with default parameters cannot adequately reproduce the depth variation of temperatures in Mulargia reservoir especially during stratification conditions.

Performance of hydrodynamic model



- Temperature profiles is an efficient way to judge hydrodynamic model performance.
- Model with default parameters cannot adequately reproduce the depth variation of temperatures in Mulargia reservoir especially during stratification conditions.
- Calibration of model parameters (eddy viscosity & diffusivity, wind drag coef.) improves model performance.

Performance of hydrodynamic model



- Temperature profiles is an efficient way to judge hydrodynamic model performance.
- Model with default parameters cannot adequately reproduce the depth variation of temperatures in Mulargia reservoir especially during stratification conditions.
- Calibration of model parameters (eddy viscosity & diffusivity, wind drag coef.) improves model performance.
- Data assimilation of surface water temperature from EO furthers improves model performance it the top layers.

2nd attempt with calibrated Hydrology and EO

https://portal.space-o.eu/portal

Partners:

SPACE-O has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 730005